LabVIEW Measurement Automation and Applications for Semiconductor Detectors

Ethan Stanifer (Miami University, Oxford, OH 45056), Grzegorz Deptuch (Fermi National Accelerator Laboratory, Batavia, IL 60510).

Abstract

Even when using the best equipment, gaining a useful amount of data from a certain device takes the experimenter a very long time if recording the data is done "by hand." The automation of measurements is a more efficient method to collect data. Measurement automation also allows measurements to be run over a long period of time or allows programming desired, precise intervals at which data is acquired. The LabVIEW programming environment was used to communicate with the measurement devices via a General Purpose Interface Bus (GPIB) protocol routed to Ethernet signal, by a GPIB-Enet device. This solution allows accessing the measurement setup from virtually any computer on the Internet. There were several dedicated LabVIEW programs developed. One such program is used to measure the current as a function of voltage or the voltage as a function of current. The main measurement is performed by a Keithley 237 source/measure device, which allows for a voltage or current source for measuring current or voltage respectively. Two Keithley 485 picoammeters, another Keithley 237, and a Keithley 2400 source/measure device can perform secondary measurements. The source setting is determined from a starting point and a step size between measurements and a signal is sent to the main Keithley 237 to set the voltage or current. Then a signal is sent to each device to collect the data at that setting. The pattern is repeated until the Keithley 237 reaches the stopping point. Most structures have various parts that will need to be measured simultaneously. The MAMBO IV — Monolithic Active Pixel Matrix with Binary Counters — pixilated detector has a buried p-doped well (BPW) in an n-doped substrate at each pixel. This creates a p-n junction like that of a diode. The junction, when reverse biased, forms an active column for detection of radiation. The detector cannot be characterized directly due to embedding of the connection to the detector terminals into the readout electronics. The guard rings on the chip are also p-doped so the actual current, originating in the volume of the detector, is measured between the power supply of the pixels side and the substrate terminal minus the current between the guard rings and the substrate. When doing this, in reverse bias, the current increases slowly until 145 V where the measured increase of current becomes uncontrolled. The chip allows exploring a few settings on the biasing, including different connections for guard rings, polysilicon electrode-gated diodes, etc. However, no effect was seen on the 145 V breakdown of the current. Another program was made that uses an HP 4284A to measure the capacitance of the p-n junction as a function of voltage. At each step, a signal is sent to the HP 4284A or a Keithley 237 to set the DC voltage and a signal is sent to the HP 4284 to collect capacitance data based on an AC stimulus imposed on the DC bias. The inverse square of capacitance as a function of voltage grows until the full depletion is reached. It was measured to 100 V approximately. Just as in the current-voltage measurement, no influence of diode gating or use of the most external n-type guard ring was seen on the depletion voltage. Performing of these various measurements at different configuration was accepted as a proof of consistency and understanding of the structure. The capacitance vs. voltage data was used to calculate an effective doping profile in another LabVIEW program. What these programs represent is a cross section of fundamental measurements that are commonly conveyed on a semiconductor detectors and electronic devices. The result that is most important in this experiment is the sheer volume of data collected in a

relatively short period of time and the fundamental nature of the measurements these programs perform. This allows an incredible range of use in a highly efficient method.